Prevalence and Treatment of Intraarticular Pathology Recognized at the Time of Periacetabular Osteotomy for the Dysplastic Hip

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Abstract

Background The indication for hip arthrotomy accompanied by intraarticular work during periacetabular osteotomy (PAO) has not been precisely defined. To validate a role for routine hip arthrotomy accompanied by intraarticular work, frequent intraarticular pathology must exist, and the adjunct procedures must not be associated with inferior relief of pain, reduced function, radiographic osteoarthritis progression, or conversion to THA.

Questions/purposes (1) What is the prevalence of intraarticular pathology at the time of PAO? (2) Does concomitant hip arthrotomy with associated intraarticular work negatively affect PAO as reflected by differences in Harris hip scores (HHS), Tönnis grade, and failure rates?

Methods We retrospectively reviewed the intraarticular findings in all 151 patients who underwent PAO

accompanied by routine hip arthrotomy and intraarticular work from 2002 to 2009. Using multivariate regression models, we compared the HHS and Tönnis grades of patients receiving arthrotomy with a cohort of 39 patients who received PAO alone.

Results The overall prevalence of intraarticular pathology identified during PAO was 89%. Eight (5.3%) failures were identified within the arthrotomy cohort with mean postoperative HHS, postoperative Tönnis grade, postoperative change in HHS, and postoperative change in Tönnis grade of 87.5, 0.7, 29.8, and 0.3, respectively. By contrast, seven (17.9%) failures were identified in the nonarthrotomy cohort. The mean postoperative HHS, postoperative Tönnis grade, postoperative change in HHS, and postoperative change in Tönnis grade for the nonarthrotomy cohort were 83.1, 1.3, 19.0, and 0.3, respectively.

Conclusions We believe the high prevalence of intraarticular pathology is sufficient to warrant routine joint inspection at the time of PAO. Hip arthrotomy accompanied by intraarticular work at the time of PAO is safe and does not impose additional patient morbidity.

Level of Evidence Level III, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

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Introduction

An expanding body of evidence implicates abnormal hip morphology as an independent cause of osteoarthritis in young adults [4, 13, 15, 16, 25, 26]. Subscribing to this theory, surgeons who perform hip preservation surgery seek to correct the pathomorphologic characteristics of the acetabulum and/or proximal femur to reestablish the

normal physiologic interplay between these osseous structures and postpone the degenerative progression. From its inception, the Bernese periacetabular osteotomy (PAO), designed to improve femoral head coverage by reorientation of the native acetabulum, constitutes a viable treatment option for young adults with symptomatic acetabular dysplasia [7, 12, 17, 21]. However, in addition to improved hip biomechanics after PAO, reorientation of the dysplastic acetabulum may also create the undesirable consequence of iatrogenic femoroacetabular impingement (FAI). Iatrogenic FAI as well as ignored intraarticular derangement at the time of PAO remain presumptive causes of clinical PAO failures [10, 19]. Thus, the PAO technique has evolved among hip preservation surgeons to include intraarticular inspection at the time of surgery to avoid iatrogenic FAI as well as identify concomitant intraarticular pathologies.

Routine hip arthrotomy in the setting of PAO is one method of direct intraarticular joint inspection and remains the senior author's (CLP) current method of choice. Nevertheless, previous reports have expressed clinical concerns over the potential increased morbidity imposed by hip arthrotomy at the time of PAO [3].

Our report seeks to answer two questions designed to refine the role of intraarticular inspection through hip arthrotomy at the time of PAO: (1) What is the prevalence of concomitant intraarticular pathology (ie, chondrolabral injury, decreased femoral head neck offset) in patients undergoing PAO for symptomatic acetabular dysplasia? (2) Does concomitant hip arthrotomy with associated intraarticular work negatively affect PAO as reflected by differences in Harris hip scores (HHS), Tönnis grade, and failure rates?

Patients and Methods

The indications for PAO in the present review were symptomatic acetabular dysplasia (greater than 6 months' duration), articular congruency, and minimal secondary arthritis (Tönnis Grade 0, 1), whereas the lone absolute contraindication was advanced osteoarthritis of the hip (Tönnis Grade 3, 4). We retrospectively reviewed all 129 patients who underwent 151 PAOs with routine anterior hip arthrotomy between 2002 and 2009. Of the 151 hips, the preoperative diagnosis included classic acetabular dysplasia in 111 hips, acetabular dysplasia with retroversion in 36 hips, and acetabular dysplasia with concomitant Legg-Calvé-Perthes disease in four hips. Eighteen patients (20 hips) reported a history of previous hip surgery. There were 88 women and 41 men with an average age of 25.5 years (Table 1). Six patients had concomitant proximal femoral osteotomy. Before 2002, routine hip arthrotomy was not

performed, providing a cohort control group of 39 hips in 37 patients. In this nonarthrotomy cohort, there were 28 women and nine men with an average age of 28.1 years. The preoperative diagnosis was classic acetabular dysplasia, defined by an anteverted acetabulum with deficiency in anterior lateral coverage of the femoral head in 37 hips, and acetabular dysplasia with retroversion, defined by deficient posterior coverage with relative overcoverage of the femoral head in two hips. The minimum followup in the arthrotomy group was 1 year (mean, 3 years; range, 1–9.5 years). The minimum followup in the control group was 1 year (mean, 6.3 years; range, 1–10.5 years). All patients were available for followup. Our institutional review board approved this retrospective study.

Arthrotomy and nonarthrotomy cohorts were evaluated with respect to independent variables including age, preoperative Tönnis grade, preoperative HHS, and preoperative severity of acetabular dysplasia as assessed by the lateral center-edge angle (LCEA), anterior center-edge angle (ACEA), and acetabular index (AI). Notable preoperative differences existed between the two groups. The arthrotomy group included a greater proportion of non-classic dysplasia (ie, retroversion), less severity in the magnitude of acetabular deficiency (AI, ACEA, LCEA), and a lower Tönnis grade (Table 1). To determine whether the magnitude of PAO correction was similar among each cohort, postoperative change in AI, LCEA, and ACEA among the arthrotomy and nonarthrotomy cohorts was examined.

All procedures were performed by a single surgeon (CLP). The Bernese PAO was performed [21] using a modified Smith-Peterson approach with the patient supine on a radiolucent table or traction table. After fixation of the osteotomized acetabular fragment, the previously tagged indirect head of the rectus femoris was mobilized for improved visualization of the hip capsule. Capsular incision was then performed along the long axis of the femoral neck and extended in both anterior and posterior directions at the level of the acetabular rim with care to avoid injury to underlying labral tissue. Retractors were placed around the superior and inferior aspect of the femoral neck for added visualization. The hip was then systematically inspected beginning with the acetabular labrum. Femoral head-neck offset was fully assessed with the assistance of gentle traction accompanied by internal and external rotation of the operative extremity as well as a dynamic impingement test (90° hip flexion, 15°–20° of internal rotation). Intraarticular intervention was predicated on intraoperative findings. Pathologic decreased femoral head-neck offset was addressed with open osteochondroplasty using a high-speed burr as previously described [8]. With respect to identified labral pathology, simple débridement was used to address ganglion cysts and degenerative labral

Table 1. Comparisons of preoperative demographics and pre- to postoperative radiographic correction between the arthrotomy and nonarthrotomy groups

Cohort variables	Arthrotomy mean (95% CI)	Nonarthrotomy mean (95% CI)	p value
Hips (classic dysplasia)	115	37	
Hips (retroversion)	36	2	
Age (years)	25.5 (24.3–26.8)	28.1 (25.6–30.6)	0.057
HHS	60.5 (56.8–64.3)	63.9 (58.7–69.0)	0.317
Tönnis grade	0.4 (0.3–0.5)	1.1 (0.8–1.3)	< 0.001
AI	16.2 (14.7–17.8)	25.8 (23.2–28.5)	< 0.001
Δ AI	13.5 (12.3–14.8)	19.3 (16.2–22.4)	< 0.001
LCEA	15.1° (13.3–16.9)	3.3° (–0.1–6.8)	< 0.001
Δ LCEA	18.1° (16.5–19.7)	24.7° (20.6–28.8)	< 0.001
ACEA	18.8° (16.4–21.2)	7.5° (2.9–12.1)	< 0.001
Δ ACEA	16.2° (14.1–18.2)	22.3° (17.4–27.3)	0.017

Data presented as mean (95% CI); Δ ACEA = postoperative ACEA – preoperative ACEA; Δ LCEA = postoperative LCEA – preoperative LCEA; Δ AI = postoperative AI – preoperative AI; HHS = Harris hip score; AI = acetabular index; LCEA = lateral center-edge angle; ACEA = anterior center-edge angle.

tears. Labral repair using the suture anchor technique previously described [10] was implemented for labral detachment at the extraarticular osseous insertion.

Postoperatively, patients were restricted to 50% weightbearing with crutches progressing to full weightbearing at 6 weeks with radiographic confirmation of PAO healing. Patients typically begin mobilizing with therapy assistance within the first 24 to 48 hours. Intermittent use of a passive motion machine (0°–30°) for the operative hip was used for patients while in bed as an inpatient. Inpatient physical therapy focused on ambulation and crutch training. Outpatient physical therapy was initiated at 6 weeks on an as-needed basis to assist patients with their transition to full weightbearing as well as abductor strengthening. Thromboembolism prophylaxis was achieved mechanically with the use of foot-based sequential compression devices and compression stockings and pharmacologically with inpatient enoxaparin (30 mg twice a day after epidural catheter removal) and aspirin as an outpatient for 6 weeks after hospital discharge.

Patients were reevaluated clinically and radiographically at 2 weeks, 6 weeks, 6 months, and 1 year postoperatively. Followup data were obtained prospectively by clinical questionnaire and yearly physical examinations obtained by a single member of the adult reconstruction team (JAE). HHS [23] was obtained preoperatively, at 6 months, and 1 year postoperatively and then annually thereafter.

The standard young adult hip radiographic series included AP pelvis as well as frog-leg lateral and false profile views of the affected hip. Complete radiographic series were obtained preoperatively and at each postoperative clinic evaluation. Complete radiographic data were available for all 190 patients. Two authors (JGG, JAE),

other than the treating surgeon, measured all radiographic parameters using standardized methodology with previously described techniques known to have acceptable interobserver reliability [1]. The LCEA, ACEA, and AI were measured as previously described [1, 6]. Acetabular retroversion was determined by the presence of a crossover sign, posterior wall sign, and/or ischial spine sign on an appropriately oriented AP pelvis radiograph [6]. Femoral head-neck offset was evaluated in the arthrotomy cohort and qualitatively defined as normal or decreased based on evaluation of available preoperative frog-leg lateral and false profile radiographs. According to criteria previously established [27], preoperative and postoperative Tönnis grades were assigned to affected hips based on review of radiographs obtained at the preoperative office visit and the most recent postoperative followup visit, respectively. Failure was defined as revision PAO or conversion to THA.

We used Student's t-test to compare the continuous variables: age, HHS, Tönnis grade, AI, LCEA, and ACEA. The chi-square test was used to compare the binary variables if the expected frequencies were all greater than five. Fisher's exact test was used to compare those binary variables in which the expected frequencies were not adequate for the chi square test. Of the variables evaluated, potential confounders were identified as age, preoperative Tönnis grade, preoperative and postoperative change in AI, preoperative and postoperative change in LCEA, and preoperative and postoperative change in ACEA because the p values for these variables were either significant or non-significant but less than 0.25. A multivariable linear regression controlling for these potential confounders was performed for the continuous outcome variables of postoperative HHS, change in HHS, postoperative Tönnis

grade, and change in Tönnis grade. For the linear regression evaluating postoperative Tönnis grade and change in Tönnis grade, we did not control for preoperative Tönnis grade because these two outcomes are dependent on this variable. A logistic regression controlling for potential confounders was performed for the binary outcome variable of failure. The data were analyzed using commercially available software (STATA Version 11, College Station, TX, USA).

Results

The overall prevalence of intraarticular pathology within the arthrotomy cohort was 89% (Table 2). We identified 31 hips with labral injury, 129 hips with decreased femoral head-neck offset, and seven hips with loose bodies or ganglionic cysts.

After adjusting for confounding patient variables, performing concomitant arthrotomy did not seem to negatively impact the outcomes given that the two groups had similar

failure rates, postoperative HHS, change in HHS, and change in Tönnis grades (Table 3). The only difference between the two groups was a lower ($p < 0.001$) postoperative Tönnis grade in the arthrotomy group (0.7 versus 1.3).

Discussion

PAO constitutes a viable treatment option for symptomatic acetabular dysplasia [7, 12, 17, 21] with reported hip survival rates approaching 84% at 10 years [17]. However, although PAO is generally an effective treatment for symptomatic hip dysplasia, a 16% THA conversion rate at 10 years [17] and a PAO failure rate of 40% after 20 years [24] have previously been reported. Of the presumed causes of PAO failure [17, 19, 20], unidentified chondrolabral injury and/or decreased femoral head-neck offset, predisposing the hip to FAI after redirection of the dysplastic acetabulum [9, 19], have been correlated with inferior improvement in hip pain and function and PAO failure. Accordingly, PAO surgical techniques for dysplastic acetabuli have evolved to include concomitant intraarticular inspection and intervention, yet few studies [11, 22] have defined the presence of intraarticular pathology in patients with symptomatic dysplastic acetabular pathomorphology. We believe it is important to define the true prevalence of intraarticular pathology recognized at the time of PAO to support the idea that arthrotomy or joint inspection should be routinely performed. Moreover, there is little evidence in the literature to support the optimal means of routine joint inspection; today both open and arthroscopic techniques could be potentially used for this purpose. Collectively, these limitations of the orthopaedic literature prompted our group to pose two questions: (1) What is the prevalence of intraarticular pathology in patients with symptomatic acetabular dysplasia undergoing PAO; and (2) does concomitant hip arthrotomy with associated intraarticular work negatively affect PAO as reflected by differences in HHS, Tönnis grade, and failure rates?

We acknowledge several limitations of the present report beyond the retrospective nature through which this study was conducted. The patient cohorts appear to be dissimilar. The two groups, although defined by the intervention of having had arthrotomy performed or not, are also defined in part temporally with cases performed without arthrotomy being performed more remotely. As a result, the arthrotomy group by default has less clinical followup. The two groups are further different in that the nonarthrotomy group had higher starting Tönnis grades and more severe dysplasia with higher starting AI and lower starting ACEA and LCEA along with an associated greater mean magnitude of acetabular reorientation. There were also more retroverted acetabuli in the arthrotomy cohort

Table 2. Prevalence of intraarticular pathology

Intraarticular pathology	Number (151)	Prevalence
Decreased femoral head-neck offset	127	85%
Acetabular labrum	31	20.8%
Other (loose bodies, cyst)	7	4.7%
All	134	88.7%

Table 3. Clinical outcome data*

Clinical outcome	Arthrotomy	Nonarthrotomy	Adjusted p value
Hips (number)	151	39	
Failure (number)	5.3% (8)	17.9% (7)	0.21 [†]
Postoperative HHS	87.5 (84.3–90.7)	83.1 (77.8–88.5)	0.717 [†]
Δ HHS	29.8 (24.2–35.4)	19.0 (11.9–26.0)	0.436 [†]
Postoperative Tönnis grade	0.7 (0.6–0.8)	1.3 (1.0–1.6)	< 0.001 [‡]
Δ Tönnis grade	0.3 (0.2–0.4)	0.3 (0.1–0.5)	0.426 [†]

Data presented as mean (95% CI); * adjusted p values reflect the use of a multivariable linear regression model to control for confounding variables; [†]controlling for potential confounders of age, preoperative Tönnis grade, preoperative AI, Δ AI, preoperative LCEA, Δ LCEA, preoperative ACEA, and Δ ACEA; [‡]controlling for potential confounders of age, preoperative AI, Δ AI, preoperative LCEA, Δ LCEA, preoperative ACEA, and Δ ACEA; HHS = Harris hip score; AI = acetabular index; LCEA = lateral center-edge angle; ACEA = anterior center-edge angle.

and increased severity of dysplasia in the nonarthrotomy cohort. These differences are likely influenced again by the temporal differences of when the procedures were performed. With time, refined surgical indications with avoidance of cases with more advanced arthrosis (ie, avoiding patients with higher Tönnis grades) along with wider spread adoption of the technique to include less severe dysplasia and more cases of retroversion that followed the surgeon's learning curve [21] are likely to have increased the likeliness to use the PAO surgical procedure in cases with less severity and more nonclassic dysplasia. Certainly the influence of the differences between the two groups along with refined surgical technique and indications may have had an additional effect on our failure rates, changes in Tönnis grade, and HHS.

Despite the aforementioned inadequacies, and the established role for PAO without routine arthrotomy in the treatment of acetabular dysplasia [28], our review suggests the prevalence of concomitant intraarticular pathology is sufficient to warrant routine hip inspection in patients selected for PAO. We identified intraarticular pathology in 89% of cases of symptomatic acetabular dysplasia. Decreased femoral head-neck offset was the largest pathologic contributor (129 of 151 patients). When repositioning the acetabulum, this finding has major clinical implications. Published reports suggest reorientation of the acetabulum may create undesirable consequences beyond the anticipated outcome of improved femoral head coverage. FAI or overcoverage was a potential pitfall of PAO as reported by Myers et al. [19] who identified posterior FAI after PAO correction of acetabular retroversion. Likewise, Dora et al. [9] reported acetabular retroversion and resultant anterior overcoverage. Even in the absence of overcoverage, PAO correction may clinically transform insignificant decreased femoral head-neck offset into a pathologic cam impingement lesion with the potential to initiate articular injury. The incidence of labral injury was fairly low in our series, 20.5% (31 of 151), which contrasts the findings of several reports [11, 22]. It is likely that our report underestimates the incidence of chondrolabral injury because actual distraction of the hip and inspection of the articular margin of the labrum were not undertaken in all cases. Thus, the preponderance of capsular margin labral injury in the present report presumably ignored existing undersurface or articular margin labral pathology, possibly resulting in a lower than expected incidence of labral pathology. Nevertheless, given these practical limitations, our data still revealed a high prevalence of intraarticular pathology, which may support routine visualization of the joint.

The second question of the study investigated whether performing concomitant arthrotomy with associated intraarticular treatment leads to higher failure rates, worsening of Tönnis grade, or inferior HHS. Opponents of arthrotomy

in the setting of PAO cite the theoretical risks of heterotopic ossification, muscle dysfunction from rectus femoris takedown, decreased hip motion resulting from capsular adhesions, and potential exacerbation of FAI as theorized by Beck [3]. Although our disparate patient populations prevent decisive cohort comparisons of clinical outcomes, the addition of hip arthrotomy at the time of PAO in the present study population did not lead to inferior results in terms of improvement in hip pain and function, radiographic deterioration of the joint, or conversion to THA.

The best method of intraarticular inspection has yet to be definitively established. In addition to arthrotomy at the time of PAO, other alternatives such as simultaneous or staged arthroscopy are currently available to diagnose and treat intraarticular pathology. Advanced imaging with contrast or noncontrast MRI or CT may make selective intraarticular inspection and treatment feasible. However, these modalities carry their own individual shortcomings. For example, conventional CT, CT arthrography, and three-dimensional pelvic reconstructions provide useful information regarding the bony architecture of the pelvis at the expense of soft tissue resolution. Hip MRI arthrography, the mainstay of soft tissue hip diagnostic imaging, achieves excellent specificity but lacks sufficient sensitivity. In a previous report from our group, sensitivity of MRI arthrography to detect acetabular chondral lesions was only 22% [2]. Suboptimal sensitivities of MRI arthrography have also been reported for detection of labral injury [5]. Hip arthroscopy may be useful to identify chondrolabral damage or femoral morphological abnormalities but it is unclear whether correction of these potentially pathologic findings is necessary if simultaneous or staged PAO is performed [14, 18].

Further evidence is required to establish a definitive treatment paradigm for young adults with symptomatic acetabular dysplasia. Given the relatively high prevalence of intraarticular pathology identified in our report, and the uncertainty of whether intraarticular treatment influences eventual improvement in hip pain, function, and survivorship, ultimately randomized controlled trials (eg, ignore intraarticular pathology versus treat at the time of or before PAO) would seem to be appropriate to definitively define the role of joint inspection and treatment in the dysplastic hip.

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